UNIVERSITI PUTRA MALAYSIA

OPTIMIZATION OF CATADIOPTRIC LOCATION FOR A CCTV SYSTEM IN AN INDOOR SPACE

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By

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Faculty : Engineering

Proper placement of cameras is an important design requirement in security camera application. Camera placement has a significance impact on the overall area coverage. The layout of security location, camera parameters and strategy of camera placement are important design consideration. This thesis focuses on maximizing the coverage area of a security camera in the IC Design Laboratory of Universiti Putra Malaysia. The current perspective stationary camera located near the lift entrance is not adequate. Thus, the use of a different camera system using catadioptric that combines lens and mirror with 360° field of view to replace the existing camera is proposed. Given the 2D plan layout in IC Design Laboratory, five cameras are mounted on the ceiling, each with a radius of coverage of 3*m*. The goal of research is to determine the optimal location of the cameras that covers maximum area of interest. Two different strategies, namely the set cover strategy and the set packing strategy are applied and compared to evaluate their effectiveness. The objective of the set cover strategy is to minimize the number of cameras while ensuring

maximum area is covered. The set packing strategy is based on minimizing the camera coverage overlap while the camera coverage remains in the specified rectangular boundary area. It is hypothesized that set packing strategy is better than set cover strategy with an accuracy of area covered is better than 90%. This is because the set packing strategy is formulated as a nonlinear problem. Thus, the cameras are able to move continuously compared to the set cover strategy which formulated as a linear problem using a discrete interval and binary integer. These strategies then be evaluated iteratively and by means of computer of simulation. The criteria of success are based on the maximum area coverage and minimum coverage overlap. Three different graphic user interface (GUI) which are made available freely for research purposes are modified and used in this study for fair comparison. The results show the set cover strategy is able to cover 91% and set packing is able to cover 93% of the observation area. The percentage of area coverage in the set packing strategy is improved by 2% compared to the set cover strategy according to the condition that had been outlined for both strategies.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGOPTIMUNAN LOKASI *CATADIOPTRIC* BAGI KAMERA LITAR TERTUTUP DI DALAM RUANGAN TERTUTUP

Oleh

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Kedudukan kamera yang sesuai merupakan keperluan yang penting di dalam aplikasi kamera sekuriti. Kedudukan kamera adalah bertujuan memberi kesan yang ketara pada keseluruhan liputan kawasan. Rekabentuk kawasan keselamatan, parameter kamera dan strategi bagi menempatkan kamera merupakan perkara yang harus dititikberatkan. Tesis ini memberi tumpuan kepada memaksima liputan kawalan bagi kamera sekuriti di dalam Makmal Rekabentuk IC di Universiti Putra Malaysia. Pada ketika ini, kamera perspektif yang terletak berdekatan pintu masuk lif tidak memadai. Oleh itu, kajian mencadangkan penggunaan sistem kamera yang berbeza dan dikenali sebagai '*catadioptric*' yang menggabungkan lensa dan kamera bagi memperolehi padangan sebanyak 360°. Berdasarkan pelan Makmal Rekabentuk IC didalam 2D, lima buah kamera yang diletakkan di syiling dengan jejari liputan adalam 3*m*. Kajian tesis adalah bertujuan bagi menentukan lokasi kamera yang optima dan memaksima liputan kawasan yang dikaji. Dua strategi yang berbeza iaitu strategi *set cover* dan strategi *set packing* digunakan dan dibandingkan bagi menilai keberkesanan setiap

strategi. Objektif strategi *set cover* adalah bertujuan untuk meminima bilangan kamera dan memberi liputan kawasan yang maksima. Strategi *set packing* adalah bertujuan meminima persilangan antara liputan kamera dan memastikan liputan kamera kekal di dalam sempadan segi empat yang telah ditetapkan. Hipotesis menunjukkan bahawa strategi *set packing* adalah lebih berkesan strategi *set cover* dan memberi liputan lebih daripada 90%. Ini adalah kerana strategi *set packing* diformula dalam ketidaksamaan linear. Oleh itu, kamera bebas bergerak secara berterusan berbanding dengan strategi *set cover* yang diformula dengan persamaan linear menggunakan diskirt jeda dan integer binari . Kedua-dua strategi dinilai secara iteratif dan disimulasi menggunakan komputer berdasarkan liputan kawasan yang maksima dan persilangan liputan yang minima. Tiga antaramuka pengguna grafik (GUI) yang boleh didapati secara percuma bagi tujuan kajian telah diubahsuai dan digunakan didalam kajian ini bagi membandingkan keberkesanan strategi. Keputusan telah mengesahkan strategi *set cover* meliputi 91% dan strategi *set packing* meliputi 93% pada kawasan pemerhatian dengan peratusan kawasan liputan untuk strategi *set packing* adalah 2% lebih baik daripada strategi *set cover* dengan berpandukan syarat-syarat yang telah ditetapkan kepada kedua-dua strategi.

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I certify that a Thesis Examination Committee has met on **28 March 2011** to conduct the final examination of **Haryati binti Jaafar** on her thesis entitled "**OPTIMIZATION OF CATADIOPTRIC LOCATION FOR A CCTV SYSTEM IN AN INDOOR SPACE**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the degree of **Master of Science**. Members of the Thesis Examination Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for other degree at Universiti Putra Malaysia or at any other institution.

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HARYATI BINTI JAAFAR
Date: 28 March 2011

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